SOME AUSTRALIAN FISH-SCALES.

By T. D. A. Cockerell, University of Colorado.

I am again indebted to Dr. Hamlyn-Harris for an interesting series of scales, which are described below. It may be worth while to give a brief account of the method of preparing scales for study. We first tried mounting them in balsam, which rendered them too transparent and obscured the markings; after various trials it was discovered that dry mounts were by far the most satisfactory. The procedure is as follows :—

(1) Remove the scales from the middle of the side of the fish, trying to avoid latinucleate (regenerated) scales.

(2) Place the scales, while wet, on a glass slide, and cover with a cover-glass, or, if the scales are large, with a second slide.

(3) Put on a clamp to keep the cover-glass down and in place, or, if a second slide is used, two or three clamps.

(4) Put on two square gummed labels, each overlapping one side of the cover-glass; or, if a second slide is used, put the labels over the ends, so as to bind them together.

(5) The next day the clamps may be removed, and the slide is finished. Scales hardly ever slip out, but it is best to keep them in flat trays or flat card-boxes.

If the scales are not mounted when removed from the fish they are best preserved dry in small paper envelopes. They must then be moistened before mounting. The apical part of the scale is covered with skin, which should usually be rubbed off.

BELONIDÆ.

Tylosurus impotens Ogilby. Moreton Bay. Scales variable, quadrate, nearly square or broader, large ones about 4·5 mm. long and broad; apical field extensive, without circuli, but frequently with irregular cracks; circuli in the basal and sublateral fields concentric, simple, or variously connected by irregular cross-lines, forming a network, the meshes of which may be very dense in the region about the nucleus. This whole system of crossed lines is of the nature of cracks or interruptions in the scale-substance, and passes into broad cracks which invade the apical field. So far as superficial appearances go, portions of the scales curiously simulate the scales of the Amphibian *Ichthyophis*. *Tylosurus acus*, from the Atlantic, differs greatly from *T. impotens* in the very broad scales, with the nucleus surrounded by circuli, which extend right across in the apical field, not leaving a large sculptureless area. In *T. acus* there are innumerable very fine radiating and transverse cracks, which have nothing to do with the circuli, and when they cross each other do not appear connected, but form a very minutely square-meshed net, as it were of independent strands.

Tylosurus schismatorhynchus Bleeker. Moreton Bay. The scales sent are small, about 2 mm. diameter, transversely elongate, nucleus apicad of middle; apical field without circuli, but with an imperfect labryinthine pattern of minute pustuliform dots and lines, and frequently with very large cracks. Circuli fine, without any cross-lines forming a network.

The following key separates the Australian species of *Tylosurus* from the Atlantic ones, so far as my material goes :—

Circuli complete around the nucleus .. .. .. *T. acus* (Woods Hole) and *T. scapularis* (Balboa, Panama Canal Zone).
Circuli interrupted above the nucleus, the apical field free from circuli .. *T. impotens* and *T. schismatorhynchus*.

T. acus is the type of *Tylosurus*, if *T. cantrainii* is that species, as has been supposed. The genus should possibly be subdivided.

SPHYRÆNIDÆ.

Sphyræna obtusata Cuv. & Val. Moreton Bay. The larger scales are about 6 mm. long and 8 broad ; smaller ones are about square, and probably come from near the tail. There is an exceedingly fine and dense system of circuli and radii, the basal circuli finely beaded, or rather crenulate. In the apical field the radii are lost, but the circuli continue, but become broken up in the submarginal area into irregular labyrinthiform markings. The basal radii are only about 112 microns apart.

This may be compared with *S. picuda* B. & S., from Tampa, Florida, which has the same dense radii and circuli, but the circular fibrillæ are considerably coarser and less distinctly crenulate. In both these species the radii are continuous, at least in the basal field, not moniliform or reduced to a series of pit-like structures as they are in *S. borealis* De Kay from Woods Hole. Thus the large-scaled species seem readily separable on the structure of the scales from the smaller-scaled forms such as *S. borealis*. The type of the genus has even smaller scales than *S. borealis*.

HOLOCENTRIDÆ.

Holocentrus ruber Forsk. Barrier Reef. Scales about 7 mm. long and 10 broad, the apical margin irregularly dentate ; apical field pitted ; five or six basal plicæ, close together, making the middle of the basal margin deeply undulate ; circuli very fine and numerous ; microscopical cracks forming lines as in *Tylosurus acus*. This is scarcely different from other *Holocentrus* scales. *H. microstoma* from Samoa has the marginal teeth much longer, sharper and closer, and the basal plicæ weaker and less regular. *H. laticeps* from Kaui has the teeth like those of *H. microstoma*, but the plicæ (only three or four) like those of *H. ruber*. *H. xantherythrus* from Hawaii has teeth of the same general type as *H. ruber*. *H. diadema* from Hawaii is like *H. laticeps*.

Thus, according to the scales, *H. ruber* and *xantherythrus* might be grouped together, apart from the other species mentioned.

TOXOTIDÆ.

Toxotes chatareus Ham. Buch. Norman River. Scales 6 to 8 mm. long and broad, subquadrate, but with rounded corners ; circuli very fine, the lateral ones

reaching the margin at an extremely acute angle ; 7 to 10 basal radii, arranged fan-wise, the basal margin only weakly scalloped ; nucleus apicad of middle ; ctenoid patch large, occupying the whole apical field, but the elements very small, the marginal teeth extremely minute. The ctenoid structures are modified circuli, into which they can be seen to pass ; they appear to be, in fact, crowded segments of circuli, all much longer than broad.

These scales suggest those of *Anabas*, but differ as follows :—Basal radii less numerous, and not nearly so close together ; lateral circuli much finer and denser ; no circuli meeting at an angle above the nucleus ; ctenoid patch much more extensive ; apical teeth much smaller. The *Anabas* examined are *A. munii* from Egypt and *A. scandens* from the Philippine Islands.

There are many families in which the scales are of the same general type as those of *Toxotes*, but in no case, so far as my material shows, is the resemblance very close.

SERRANIDÆ.

Interpreting this family in a broad sense, the following may be included :—

Radial system consisting of a more or less elongate ring in the nuclear region, from which proceed strong radii, the basal ones many and long, the apical ones short ; circuli extremely fine *Plesiops nigricans* Rupp. (Moreton Bay).

Radii ordinary, all basal ; no nuclear ring .. .. 1.

1. Scales broader than long ; basal radii 4 to 6 ; apical circuli transverse ; scales wholly cycloid .. *Ambassis nalua* Ham. Buch. (Cape Bowling Green).

Scales longer than broad, with ctenoid elements, though not always with marginal teeth .. 2.

2. Ctenoid patch large, marginal teeth numerous and well developed ; scales moderately broad .. *Plectroplites ambiguus* Rich. (Condamine River).

Ctenoid patch small, marginal teeth few or absent, scale narrower .. .. 3.

3. Ctenoid (tooth or spine like) elements only developed in a patch just above the nucleus, the region beyond with broken remains of circuli, more or less V-shaped, consequently no apical teeth whatever .. .. *Epinephelus lanceolatus* Forsk. (Moreton Bay).

Ctenoid elements reaching the margin, where there are projecting spine-like teeth ; scales small and very narrow .. .. *Oligorus macquariensis* C. & V. (Condamine River).

It will be seen that at least three entirely different types of scale are represented here. It must be stated, however, that some *Plesiops* scales (*P. corallicola*, Eton Is.) have the nucleus very near the apex, with long radii proceeding fan-wise basad from it, no radial ring and no apical radii. In *P. corallicola* scales, whether as just described or with the radial ring and apical as well as basal radii, there are strong ctenoid elements on the apical margin, with many sharp teeth. In *P. nigricans* the ctenoid features are less distinct, largely concealed by the dark skin. According to Boulenger, *P. corallicola* is not to be separated from *P. nigricans*.

Ambassis constitutes a very distinct group, Ambassinæ or Ambassidæ. Other species of *Epinephelus*, as *E. niveatus* and *E. megachir*, have very strongly developed apical teeth, so *E. lanceolatus* appears to be an aberrant species. *Oligorus* scales closely resemble those of *Epinephelus niveatus* C. & V., from the Atlantic.

APOGONIDÆ.

I do not believe that the rules, correctly interpreted, require us to write *Amia* for *Apogon*.

Glossamia aprion Rich. Norman River. Scales transversely oval or oblong, about 4 mm. long and 5 broad, some a little larger; corners rounded; nucleus a short distance above middle; basal radii delicate and numerous; basal margin only feebly crenulated; radii above the nucleus complete, rounded, not angled; ctenoid patch very distinct, the elements elongated; marginal teeth numerous, small. The submarginal ctenoid elements are much longer and more spine-like than in *Cheilodipterus nigrotæniatus* Sm. & Rad. (U. S. Nat. Mus.; type).

Apogon fasciatus Shaw. Moreton Bay. Scales transversely elongated, about 4·5 to 5·5 mm. long and 5·5 to 6·5 mm. broad; differing conspicuously from *Glossamia* in the subapical nucleus (which, with the obtusely angulate apical margin, recalls the Gobiidæ, although the ctenoid elements are in many rows), and also in the deeply crenulate basal margin. The marginal teeth are small and very sharp; the submarginal ctenoid elements are relatively broad and short, of the same general type as those of *Cheilodipterus*. In this last feature *Apogon*, *Cheilodipterus*, and *Apogonichthys* fall together, apart from *Glossamia*.

Through the kindness of Dr. H. M. Smith I have scales from the types of a number of species of *Apogon* (*Amia* S. & R.) lately published by Smith and Radcliffe. They entirely confirm the generic characters ascertained from *A fasciata*. In *A. uninotatus* (S. & R.) the scales are unusually short and broad, and the basal circuli are very fine and close. There are good specific characters in the structure of the ctenoid elements, which are hard to describe. I figure those of *A. uninotatus*, *A. nigrocinctus*, and *A. fasciatus*.

HÆMULIDÆ.

Pomadasis hasta Bloch. Moreton Bay. Scales subquadrate, about 5 mm. broad and long, the nucleus far above the middle; basal radii ordinary, about 12; basal margin moderately crenulate; ctenoid area large, marginal teeth small and sharp; ctenoid elements much like those of *Apogon nigrocinctus*, the submarginal elements as broad as long, much as in the Percid *Boleosoma*. There is no material difference from the scale of *Orthopristis*. *Pomadasis macracanthus*, from Balboa, Panama Canal Zone (Meek and Hildebrand, U.S. N.M.), presents no material difference in the scales. The *Pomadasis* scale represents a very conservative acanthopterygian type.

THERAPONIDÆ.

Therapon fuliginosus Macleay. Burdekin River. Scales longer than broad, about 6 mm. long and 4·5 broad, but variable; about 12 to 15 basal radii; basal margin scarcely crenulate; ctenoid patch large.

T. unicolor Gthr. Burnett River. Scales little longer than broad, or even sometimes broader than long, the largest not over 5 mm. long; basal margin hardly scalloped or crenulate.

T. percoides Gthr. Walsh River. Scales square, about as broad as long, the largest about 4 mm. long; basal margin finely scalloped.

T. jarbua Forsk. has the smallest scales, according to my material, with the basal margin distinctly scalloped.

All these keep the generic charcaters indicated for *T. jarbua* in Mem. Queensl. Mus., vol. ii, p. 56. They are very ordinary acanthopterygian scales, distinguished from those of *Pomadasis* by the closer basal radii.

SPARIDÆ.

Lateral circuli transverse or somewhat oblique .. .. 1.

Lateral circuli vertical, or if oblique, more nearly vertical than transverse .. .. 2.

1. Upper lateral circuli broken into interrupted lines, irregular and often hooked at end : radii five or six, none reaching lateral margins .. .. *Pentapus aurifilum* Ogilby (Off Cape Moreton).

Lateral circuli entire, normal, but there is an area between the uppermost circuli and the ctenoid area which is entirely free from sculpture .. *Dentex spariformis* Ogilby (Off Cape Moreton).

2. Basal radii six to nine, none reaching lateral margins ; region above level of nucleus with some small perforations ; ctenoid structures as in *P. aurifilum*, but submarginal elements shorter *Pentapus setosus* C. & V. (Moreton Bay).

Some of the radii reaching lateral margins (not always in *Sparus australis*) .. .. 3.

3. Lateral circuli oblique, forming an angle of perhaps 30 degrees with margin; ctenoid elements weak .. .. *Sparus australis* Gthr. (Moreton Bay).

Lateral circuli vertical, parallel (or almost parallel) with margin .. .. 4.

4. Scales quadrate, about as broad as long ; ctenoid patch large ; submarginal ctenoid elements elongate .. .. *Lethrinus glyphodon* Gthr. (Moreton Bay).

Scales broader than long (some are square in *Gymnocranius*) .. .. 5.

5. Submarginal ctenoid elements elongated .. .. .. *Lethrinus nebulosus* Forsk. (Moreton Bay).

Submarginal ctenoid elements short ; scales larger .. *Gymnocranius bitorquatus* Ogilby (Moreton Bay).

The characteristic ctenoid elements of *Lethrinus* (*L. harak*) were described in Mem. Queensl. Mus., vol. ii, p. 56. The additional species agree.

The two species of *Pentapus* in the above key seem to be subgenerically distinct. The European *Dentex vulgaris* has the lateral circuli oblique, practically as in *Sparus australis* ; it is very different from *D. spariformis*, which is perhaps not congeneric. *Sparus sarba* has the upper lateral circuli quite transverse, but the lower ones are oblique.

CHÆTODONTIDÆ.

Holacanthus nox Bleeker. Barrier Reef. Scales small, the ctenoid area with strong continuous ridges, ending in teeth. In Mem. Queensl. Mus., vol. iii, p. 44, it is stated (whether by a slip of the pen or a misprint I do not know) that *H. bicolor* has small separate elements in the basal part of the ctenoid area. The statements there made (section 4) refer not to *H. bicolor* but to *H. sexstriatus*. The next section (5) properly refers to *H. bicolor*. *H. nox*, at least in some scales, has very distinct basal radii, with the basal margin strongly scalloped.

Holacanthus imperator has complete rods in the ctenoid area, as in *bicolor* and *nox*.

MONACANTHIDÆ.

Cantherines trachylepis Gthr. Moreton Bay. The thick skin is minutely pigment-dotted, and out of it arise, at regular intervals, the rows of five (rarely four) sharp short spines representing the scales. The scales are expanded beneath the skin, the concealed portion consisting of coarse fibrillæ, which give it a striated appearance. These scales are not like those of *Monacanthus* or *Ceratacanthus*; they are rather more suggestive of *Balistes*.

SCORPÆNIDÆ.

Apistus macrolepidotus Ogilby. Hervey Bay. Scales elongate, 3 to 4 mm. long, 1·75 to 2·25 mm. broad; sides approximately parallel; nucleus far above middle; circuli dense; basal radii about 10 to 12, strong; basal margin scalloped; apical margin with immense irregular teeth, supported by median slender ribs, these teeth four to eight, or occasionally only three, one sometimes larger than the others. This is a very unique and remarkable scale, remotely approaching *Sebastes*.

I take the opportunity to note that *Pterois lunulata* Schleg., from Misaki, Japan (Stanford University), has short scales, about as broad as long, of the same type as those of *Scorpæna plumieri* Bl., but whereas in the *Scorpæna* there are rudimentary denticles, in the *Pterois* the scale is strictly cycloid, with the transverse apical circuli zigzag or strongly wavy.

DACTYLOPTERIDÆ (CEPHALACANTHIDÆ).

Ebisinus procne Ogilby. Moreton Bay. These scales have a sharp central keel and a dentate margin, entirely in the manner of *Cephalacanthus volitans*. The marginal teeth number about ten.

PTEROPSARIDÆ.

Parapercis nebulosa Quoy & Gaim. Moreton Bay. Scales like those of *P. cylindrica*, but considerably longer.

SOLEIDÆ.

Brachirus niger Macleay. Moreton Bay. Scales greatly elongated (about 4·25 mm. long and 1·50 broad), parallel-sided, nucleus far above the middle, basal radii about 6 to 10; apical teeth about 8 to 12, long and sharp. These scales are from the pigmented side of the fish. The ctenoid elements are quite as in *Solea*, with the same characteristic submarginal structures (*see* fig. 49, Bull. U.S. Bur. Fish, xxxii, p. 172).